Charles F. Dunbar Esq respects of A. Williams

AN IMPORTANT DISCOVERY.

GOLD

IN AN

AMORPHOUS AND CHEMICALLY COMBINED CONDITION IN NATURE.

A Pamphlet,

CONTAINING

A PAPER READ BEFORE THE POLYTECHNIC ASSOCIATION OF
THE ACADEMY OF ARTS AND SCIENCES, IN
NEW YORK, MARCH 12, 1868,

ON THE

NATURE, PROPERTIES, AND RELATIONSHIP OF GOLD.

ALSO,

DESCRIPTION OF SEVERAL NEW PROCESSES
FOR EXTRACTING THE PRECIOUS
METALS FROM THEIR ORES.

BY PROF. A. L. FLEURY,
OF NEW YORK.

Price, 50 Cents.

BOSTON:
FRED. B. DAKIN, PRINTER,
50 BROMFIELD ST.
1868.

AN IMPORTANT DISCOVERY.

GOLD

IN AN

AMORPHOUS AND CHEMICALLY COMBINED CONDITION IN NATURE.

A Pamphlet,

CONTAINING

A PAPER READ BEFORE THE POLYTECHNIC ASSOCIATION OF
THE ACADEMY OF ARTS AND SCIENCES, IN
NEW YORK, MARCH 12, 1868,

ON THE

NATURE, PROPERTIES, AND RELATIONSHIP OF GOLD.

ALSO,

DESCRIPTION OF SEVERAL NEW PROCESSES
FOR EXTRACTING THE PRECIOUS
METALS FROM THEIR ORES.

BY PROF. A. L. FLEURY,
OF NEW YORK.

Price, 50 Cents.

BOSTON:
FRED. B. DAKIN, PRINTER,
50 BROMFIELD ST.
1868.

INTRODUCTION.

In the following paper I have embodied my own ideas concerning the existence of Gold in Nature. The presence of Gold in an **Allotropic, Amorphous,** and **Oxidizable** condition, as also the existence of **Gold as an Oxide Chemically combined with Silicic Acid** (this latter condition has long been suspected by Professor Bischoff in Bonn. See Elements of Chemical and Physical Geology published by Cavendish Society, Vol. III. pages 534, 535), are subjects of the greatest interest, for they seem to throw light on the many discrepancies in our metallurgical processes, and explain why it is, that every year twenty-five millions of dollars in Gold, are left in the tailings as refuse.

We do in our laboratories, metallurgic, and manufacturing establishments nothing else but *attempt* to imitate Nature; we have succeeded in preparing *artificially* a vast number of *chemical* combinations of Gold with other elements, but still persist in denying to Nature the same privilege. We need only look and search for truths in the *great book of Nature*, and we will find them; our test-books should be our *guides*, but not be our *infallible* Precepts.

What a sneer would a man have provoked among our learned geologists had he, only a few years back, instituted a search for Gold in the Pennsylvania oil region! and still, Gold has been discovered there and in many places where Science denied its existence.

That gold existed in Pyrites and other Sulphurets has been known for many years, but who suspected that a large portion of Gold would pass off with the Sulphur and acid vapors when the ores are roasted?

Why do our chemists find hundreds of dollars of Gold per ton in ores which, when worked at the mill, do not pay the expense of mining?

There is no doubt there have been many swindles perpetrated upon the public, during the last Gold mania, but I feel satisfied in my mind that many ores that are now deemed worthless will enrich some men beyond their own expectations.

GOLD;

ITS HISTORY, NATURE, RELATIONSHIP TO OTHER ELEMENTS, AND THE BEST KNOWN METHODS OF EXTRACTION.

A PAPER READ BEFORE THE POLYTECHNIC ASSOCIATION OF THE ACADEMY OF ARTS AND SCIENCES IN NEW YORK, THURSDAY, MARCH 12, 1868. By Prof. A. L. FLEURY, of New York.

WHAT a history of joys and sorrows, of expectations and disappointments, of virtue and vice, of folly, passion, and crime, could many a small Gold dollar, or ducat, relate, were it gifted with intelligence and speech! What curious hiding-places and scenes could many an old Gold coin describe!

However interesting and instructive as such a history of Gold among men would be, it is not the one I propose to bring before you this evening; it is the *History of Gold in Nature* I contemplate to lay before you. We will trace the precious metal to its rocky hiding-places, and attempt to unravel some of the mystery that seems to enshroud it; we will then give a brief account of its *physical* and *chemical* properties, then review its peculiar *relationship* to other elementary substances, and finally state some of the most effective and successful processes for its extraction from the various ores.

Please give me your undivided attention, and I hope to be able to interest you.

All modern accounts agree in tracing the origin of Gold to veins of quartzose and schistose character. Wherever Gold, is found, either in the sand of rivers, or in diluvial deposits, or in rocks, we ever find it enshrined, or, at least, in close proximity to Silica, either as Quartz, or as Clay Slate, or as another more complex siliceous combination. There are some exceptions, however, but these are few in number.

Gold, in varying proportion, is found in most of the metallic Sulphurets, Arseniurets, and other similar compounds, either combined or free; but these are mostly embedded in quartzose veins, or disseminated in schistose rocks.

In order to understand more fully why Gold is found in the Sulphurets and other analogous combinations, and these again are enclosed in Quartz veins, we must trace out the *Origin of Quartz itself.*

We have here several pieces of Quartz; they all contain various metallic sulphurets, and some show traces of free Gold, all of which are firmly embedded in the crystalline siliceous mass. How did the Sulphurets and the Gold get into the Quartz, and what agency forced the Quartz through the fissures of the rocks?

We all know that Quartz is a product of aqueous and not igneous origin. We have ample proofs to that effect in the presence of volatile metals, such as Antimony, Arsenic, Zinc, and others, also in the presence of water in geods, and the close proximity to hydrated and carbonated minerals. The theory of the injection of Quartz as a glassy, highly-heated mass, by volcanic agency, has been superseded by the more sensible one of aqueous action.

The following thoughts I read last fall before the Association of Natural History in Boston, and as they received the attention of most of its scientific members, I will state them here in as few words as possible.

Reading the clear and beautiful explanation given by Prof. Fremy, in Paris, of the origin of the Gayser springs, and studying over his experiments with Bisulphide of Carbon on Silica Alumina, etc., I could not help coming to the conclusion that *nearly all Quartz in nature owes its existence to the decomposition of Sulphide of Silicium by water.*

To make this idea clear, I must digress a little, and state my own views on the condition of the interior of our globe.

Firstly, I believe in the existence of intense heat in the centre of our globe, — a heat of such intensity, that all the elements are thereby kept in an incandescent gaseous condition.

Around the gaseous commingled matter I conceive, at first, a very liquid, melted mass, attached to a half solid, somewhat plastic crust, which, as it gets farther from the centre, cools, and in its effort of expanding, breaks into fragments. The crust of our earth (probably forty miles in thickness), I conceive full of crevices and immense caverns, some of which, by passages of various dimensions, communicate with each other, and are ever changing, according to outward radiation of heat, condensation, and cooling of matter.

For the sake of illustration, I will call Granite a *primary rock*, though I think that many rocks of by far greater age than Granite exist below, which to *our* surface rocks compare as *our soil does to our own rocks.*

When Granite, or any other compound or simple Silicate, is, while under pressure and a bright red heat, exposed to vapors of Carbon and Sulphur (both of which exist in abundance in the interior of our earth), the Silica is decomposed: — the Oxygen of the Silica combines with the Carbon and forms Carbonic Oxide and Carbonic Acid, while the Sulphur seizes upon the Silicium and forms *Sulphide of Silicium*, a white earthy mass, withstanding a great degree of heat.

As the interior crust of our earth is continually acted upon by cosmic disturbances, either by the gravitation of our own terrestrial substance, or by solar, lunar, or planetary influences, a gradual or sudden condensation, cooling, and breaking of the harder portion of the rocks takes place; water rushes into the crevices, and, reaching the Sulphide of Silicium and other Sulphides, is instantly decomposed in its turn by the Sulphide of Silicium into Oxygen and Hydrogen. Sulphuretted Hydrogen Gas and a Hydrate of Silica are formed, both of which are soluble in water, and easily carried along by steam. The upper cavities, mostly filled with water impregnated with Carbonic Acid, which in itself is a great solvent and combining medium for metallic oxides, such as Iron, Copper, and others (all of which, no doubt, exist dissolved in this water), are suddenly broken into by these water vapors, carrying the hydrated Silica and Sulphuretted Hydrogen with them, and the Oxides, Hydrates, and other metallic solutions are broken up; the Sulphur of the Sulphuretted Hydrogen seizes upon the metals, forms therewith Sulphides, and the whole mass is forced upward, together with the liquid Quartz. The hydrated Silica, carrying the heavier Sulphuretted metals in the centre, comes in contact with the cool atmosphere and the cold sides of the crevices, and a *Gelatinization* and gradual Crystallization takes place, — the Sulphurets crystallizing in the Quartz.

I can reproduce, *artificially*, in a small way, what nature has done on a large gigantic scale: — I can heat Granite to a white heat, expose it to the vapors of Bisulphide of Carbon, then treat the Sulphides resulting therefrom by steam, and carry the Hydrate of Silica and Sulphuretted Hydrogen into a basin containing Carbonate of Iron or other metallic solution, when the Silica will be seen to gelatinize slowly, and the Sulphurets of Iron or Copper crystallize in the Silica. After this digression we will return to our chief subject, Gold.

I believe that Gold is an *elementary* metallic substance like

Iron, Copper, Zinc, etc., and have no faith in the alchemistic idea of commuting baser metals into Gold, which idea, from time to time dives up here and there among the *savans* on the other side of the water. (Perhaps no better origin could be ascribed to the element Gold than that the President, ruling the regions below, has raffined his own favorite beverage, *Brimstone*, into Gold, and has presented it as a fit material for a golden calf to Moses and Aaron and our anxious Bulls and Bears of the gold-room.)

Experiments which I have made in my own laboratory have led me to the following original ideas: —

1. That Gold exists in nature in two distinct *allotropic* conditions: In a *metallic*, *molecular*, *crystalline state*, withstanding the action of oxidizing agents under ordinary conditions, and in an *amorphous*, *not metallic* and *oxidizable* form. Plumbago and Lampblack may illustrate this idea. The former, like metallic Gold, is heavy, a good conductor of electricity, and has all the appearance of a metal, while the latter, the Lampblack, is easily oxidized, is light, is a non-conductor of electricity, and is amorphous.

2. That in Sulphurets the Gold is mostly present in both modifications, and may sometimes be found in a chemically combined state.

I will here cite a curious experiment, which gives a fair illustration of what I say: —

A quantity of finely pulverized Sulphurets from a rich mine in Colorado, Montana, or California is, at first, carefully treated in a close vessel, with Mercury-vapors, then cooled and washed, the Mercury separated, and the resulting quantity of Gold weighed. The Sulphurets, after having been thus treated, are then mixed with fine charcoal dust and Plumbago, an equal quantity of each, placed into a carbon crucible, and this into a porcelain retort, which has a tube attached, through which the gases that escape during the heating of the crucible can be passed into a chlorine solution. When the crucible is slowly brought to a red heat, Bisulphide of Carbon issues forth, and at the same time the chlorine solution darkens; when tested with Sulphate of Iron or Oxalic Acid, a precipitate of Gold is obtained. This *volatilized* Gold *is not absorbed by* Mercury. If the desulphurized remaining ore is then again treated with Mercury-vapor, as before, cooled and washed, a third quantity of Gold is separated.

This, and a number of other observations have brought me to think that Gold *was*, and still *is*, *existing* in nature in a *chemically combined state*, *not only with Sulphur*, but also with *Silica* as a *Silicate of the Oxide of Gold* $Au\,O\,Si\,O^3$, as a *Silicide of Gold* $Au\,Si$, and, perhaps, in many other similar combinations. I ask you simply, my hearers: *Did we ever look for Gold in a different state from the metallic?* We speak of invisible Gold, prepare in our laboratories solutions of Gold, Auric Oxides, Sulphides, and other combinations, and deny to *nature*, *which we only imitate*, the right and privilege to have used the same means, simply because our books say otherwise or nothing of it! Why can we not *oxidize* Gold in its metallic state *without first dissolving it?* I think it is simply for the reason that it has to be brought to an *atomic*, *amorphous state*, and *subdivision*, before it is acted upon by Oxygen or Sulphur.

Rose-colored Quartz is by miners considered quite a reliable indication that Gold may be expected at greater depth. By smelting glass with Purple of Cassius, Oxide of Gold, Auric Acid, or even finely divided precipitated Gold, we produce a splendid crimson glass, which, if a *smaller quantity* is used, has the *color of rose.* If rose-colored Quartz is chemically decomposed with Fluoride of Calcium, Gold can easily be detected in the result. I have witnessed many experiments, and made myself, while in Boston, a number of tests with various Fluorides, such as Cryolite, Fluorspar, and the so-called Stevens Flux, — all giving me the evidence that the opinion expressed by Prof. Bischoff in Bonn, the best authority we have in chemical geology, that Gold, as well as Platinum, may derive its origin from the decomposition of Silicates, is well founded.

We will now take up the next point, and give a brief account of the

Physical and Chemical Properties of Gold.

Pure Gold is of a reddish yellow color, and possesses a high metallic lustre. In the pulverulent state it is brown and dull, but acquires metallic lustre by pressure. The specific gravity of melted Gold is 18.2, of hammered Gold, from 18.3 to 19.4. Finely divided Gold precipitated by Sulphate of Iron was found to vary in density from 19.55 to 19.72, and when precipitated by Oxalic Acid, its density was 19.49. Its chemical equivalent of combination is 196.44, its formula Au., *Aurum;* its alchemistic sign, ⊙ or Sol, the Sun, the emblem of purity.

In a pure state, Gold is softer than Silver, and nearly as soft as Lead, but its tenacity is so great that it may be drawn out into very fine wire. It is extremely malleable, and can be hammered out into leaves only $\frac{1}{370000}$ of an inch in thickness. The same amount of leaves (370,000) made of printing paper would reach nearly a hundred feet high! *A single grain* of gold may be extended over 57.75 square inches of surface, or drawn out into a wire 500 feet long. Reamur, by rolling out a fine Silver wire covered with Gold, reduced the coating of Gold to the twelve millionth of an inch in thickness, and the surface appeared to be perfect when viewed under the microscope.

Gold does not *directly* combine with Oxygen, and therefore suffers no change by exposure to air and moisture at any temperature, not even by being kept in a state of fusion in open vessels.

I intend, so soon as I shall have sufficient time, to institute a series of experiments for the purpose of ascertaining the influence of the metalloids in vapor form on *precipitated* Gold under different degrees of heat, also how far electricity influences its chemical character and stability.

Gold, under ordinary circumstances, and in its metallic form is not attacked by the mineral, or any of the simple acids, except by Selenic Acid, with the aid of heat. To this must be added the interesting discovery of Prof. Henry Wurts, of this city, that Gold is soluble in Sesquichloride of Iron and *Ferric* solutions in general, — a fact that is of great importance, and deserves a most thorough investigation. The alkalies do not affect Gold. It is, under ordinary circumstances, not acted upon by Sulphur, and, therefore, Sulphuretted Hydrogen is not decomposed by it, as is the case with Silver. Iodine has only a weak action upon it, but Bromine and Chlorine attack it easily at ordinary temperatures, and it is dissolved by any substance that liberates Chlorine. It is therefore dissolved by Hydrochloric Acid, if Binoxide of Manganese, Chromic Acid, etc., be added. The usual solvent is a mixture of one part of Nitric and four parts of Hydrochloric Acids. The proper solvent for Gold is *nascent* Chlorine, which is eliminated by the mutual action of the mixed acids.

Gold is one of the most perfect conductors, both of heat and of electricity. It fuses at bright red heat, the temperature of which has been estimated at 2016° F. It is, therefore, less fusible than either Silver (1873° F) or Copper (1996° F). In fusion it exhibits a bluish green color. Gold contracts on cooling, and cannot advantageously be employed for castings. Native Gold affords numerous well-defined crystals belonging to the cubic system ; and of these the greater number is affected by the faces of the regular octohedron.

Gold has a peculiar metallic lustre, which, if once seen, can scarcely be mistaken. Its malleability and equally reflected light, when held at varying angles, distinguishes Gold from Pyrites and Sulphurets.

The following are the chemical tests given by Muspratt:—

Sulphate of Iron gives, in acid solution, a brown precipitate. If very dilute solution, only a blue coloring.

Protochloride of Tin. In dilute solutions a purple red coloring; when strong, an almost brown precipitate.

Metallic Zinc. Precipitates metallic Gold as a voluminous brown precipitate.

Potassa in Excess. No precipitate; after some time a green coloring and slight precipitate.

Ammonia. Yellow precipitate of Fulminate of Gold.

Carbonate of Soda or Potassa. No precipitate in cold solutions, but when heated, voluminous precipitate, like Oxide of Iron.

Bicarbonate of the same. No precipitate.

Carbonate of Ammonia. Behaves like Ammonia, Carbonic Acid being evolved.

Oxalic Acid. Dark, greenish black precipitate, more quickly produced by heat.

Tartaric Acid and Tartrate of Soda. Dark precipitate when boiled.

Sulphide of Ammonium and Sulphuretted Hydrogen. Dark brown or black precipitate.

The usual tests for Silver are the following:—

Potassa. Brown precipitate; becomes black on boiling.

Carbonate of Soda or Potassa. White precipitate, soluble in excess of Ammonia.

Carbonate of Ammonia. White precipitate, soluble in excess of the same.

Phosphate of Soda. Yellow precipitate, soluble in Ammonia.

Oxalic Acid. In neutral solution a white precipitate.

Sulphuretted Hydrogen and Sulphide of Ammonium. Black precipitate.

Hydrochloric Acid. White, curdy precipitate, soluble in Ammonia.

Zinc, or Copper. Precipitate, white metallic Silver.

Sulphate of Iron. In neutral solutions white metallic Silver.

We will now rapidly glance over the series of *Chemical combinations*, which we have succeeded in preparing with Gold and other elements by artificial means.

Aurous Oxide. Au O. Formed by precipitating Protochloride of Gold with a cold, dilute solution of Potassa. Blackish violet when moist, bluish violet when dry. This Oxide is permanent at ordinary temperatures, but decomposes at 250° C.

Purple Oxide of Gold is formed, according to Berzelius, when a powerful electric current is passed through a thin Gold wire. The Gold burns with a green light, and is converted into vapor, which deposits itself on the adjacent surfaces in the form of Gold purple. This purple Oxide is formed even in air two hundred times rarified. The presence of other bodies favors the oxidation of Gold at high temperatures by predisposing affinity, — the oxide formed being generally red.

When Gold leaf is triturated with various substances, and exposed to the blowpipe flame on a small cupel, the following results are obtained: *With Potassium:* The alloy oxidizes quickly as it forms, and is converted into a *black powder* which fuses into a *violet glass* with Silica and Borax. *With Hydrate or Nitrate of Baryta:* The Gold disappears and colors the Baryta red brown. *With Hydrate of Lime:* The Lime acquires a *reddish or a bluish gray color.* When Gold leaf is placed in a crucible with Hydrate of Lime, in alternate layers, and ignited, the Gold disappears and the Lime acquires a *flesh color.*

With Silica containing Potash: Red coloring accompanied by disappearance of the Gold. With Zinc: Gray powder, the gold disappearing. *With Iron filings:* The Gold disappears quickly, and yields a gray mass; and if this substance be ignited with fresh Gold leaf, as long as the latter disappears, a *red* mass is obtained still having the form of the filings, and very slightly soluble in dilute Sulphuric Acid, the solution not being attended with evolution of gas (T. A. Buchner Rep. 27, 1). It is in this red form that Gold enters into glass fluxes.

Auric Acid, or Teroxide of Gold. *Au* O^3 produced by precipitating a hot aqueous solution of Terchloride of Gold, free from excess of hydrochloric acid, with a strong excess of Potash. There are many other methods of preparing it. It is a brown-black powder, having a conchoidal fracture. Decomposed by light, or *at an incipient red heat*, into metallic Gold and Oxygen Gas; it gives up its Oxygen to vegetable acids, and many other substances. When boiled with Potash lye, it is resolved into Protoxide of Gold and Aurate of Potassa.

Hydrated Auric Oxide, AuO^3+HO. This is obtained by mixing a solution of Terchloride of Gold, not containing free acid, with a quantity of Potash, only just sufficient to neutralize the Hydrochloric Acid, and repeatedly washing the *reddish yellow* precipitate, which does not appear till after the lapse of several hours. The Hydrate, after drying in the air, which takes place but slowly, exhibits a chestnut brown color. When heated to one hundred degrees C, or when treated with

Potash solution, it gives up its water, and is converted, with diminution of volume, into the black oxide, part of which, however, is reduced to the metallic state. This Hydrate is perfectly soluble in Hydrochloric Acid.

Identical with this, appears the precipitate which Vauquelin obtained, by heating the acid Gold solution with pure Potash or Carbonate of Potassa. This precipitate when recently formed, was of loose texture, and *of reddish-yellow color;* resembling, when deprived of its moisture, *dried blood.* With acids it forms the salts of Auric Oxide, or *Auric Salts*, and with the alkalies and some of the earths compounds called *Aurates.*

Gmelin describes another very interesting combination with Oxygen. *Perauric Acid.* $Au\,O^5$; but this seems to be a mixture of oxides.

Gold and Sulphur. Protosulphide of Gold $Au\,S$. A black-brown powder, exhibiting a deep yellow streak, is produced by passing Sulphuretted Hydrogen through a boiling solution of Chloride of Gold.

Tersulphide of Gold $Au\,S^3$. By precipitating a solution of Terchloride of Gold with Sulphuretted Hydrogen, or an alkaline Hydrosulphate at ordinary temperature, a *black precipitate* results. According to Levol (N. Ann. Chim. Phys. 30, 355) the precipitate thus formed consists of $Au\,S^2$ *which contains water*, and does not give it up till heated to 140° C. It is also prepared by fusing Gold in excess with Pentasulphide of Potassium and dissolving the fused mass in water and precipitating by an acid. The Sulphide of Gold then falls down in *deep yellow flakes* which turn *brown* on drying. (Berzelius.)

I will only quote a *few* more of the artificial Gold combinations, which of late have grown to a formidable number.

Protochloride of Gold $Au\,C$. *Yellowish white*, formed by heating Terchloride of Gold to the melting point of Tin, in a porcelain basin. Hydrogen Gas, passed for some time through a neutral solution of Chloride of Gold, gives a fine *purple-red* color *without* forming a precipitate.

Terchloride of Gold $Au\ Cl^3$. Gold leaf heated in chlorine Gas *absorbs it* without visible combustion. Gold leaves and finely divided Gold obtained by precipitation *dissolves in heated Hydrochloric Acid.* Gold dissolves, even at ordinary temperatures, in *Chlorine water*, in mixture of Nitric Acid with Hydrochloric Acid, Salammoniac, and common Salt, and in mixtures of Hydrochloric Acid with Nitrates or with Chromic Acid.

$$Au + N\,O^5 + 3\,H\,Cl = Au\,Cl^3 + 3\,H\,O + N\,O^2.$$

It is very interesting to study the action of the various metals and other elements as well as compounds on the solutions of Terchloride of Gold. Some precipitate the Gold as yellow metallic Gold, some as a black powder, and some as the *red oxide.* In short, there is evidently a large field for research.

I extract the following curious item from Graham's Handbook of Chemistry : —

"*Gold and Silicium.* Finely divided metallic Gold, Chloride of Gold, fulminating Gold, the precipitate thrown down from solution of the Chloride by Potash, or by Silicate of Potassa, the Purple of Cassius, etc., fused at a continued gentle heat, with a glass containing Oxide of *Lead*, impart to it, according to circumstances, a *yellow* or a *purple-red* color. Among the various explanations which have been suggested for the red coloring which has been imparted *by heat* to *colorless* auriferous glass, the most probable, according to H. Rose (Pogg. 72. 556), is that the colorless glass contains a *Silicate of Aurous Oxide*, which requires a high temperature to produce it, and *can bear* *that temperature* without decomposition; but that when it is heated to a lower temperature, part of the Aurous Oxide separates out, and produces the color, and finally, at a stronger heat, the separate Aurous Oxide is reduced. and the glass thereby rendered liver-colored and opaque."

It would take us too long were we to review even the most important combinations of Gold with other substances; enough, however, can be seen from this, that there must *exist similar* combinations in nature; we have only to look for them, and specially among the Silicates, the combinations of Gold with metalloids and easy volatile metals, such for instance as Gold and Arsenic, Bismuth, Antimony, all of which form alloys with it, and change the point of volatilization.

For instance Arsenide of Gold, a gray brittle alloy, is easily fusible, and does not give up all its Arsenic even when fused for two hours in an open crucible.

SPONGE GOLD.

Dr. C. T. Jackson, of Boston, discovered the manufacture of Sponge Gold, capable of welding while cold, by adding to a concentrated solution of Chloride of Gold a small quantity of Oxalic Acid, and then a sufficient quantity of Potash, or Carbonate of Potash, to dissolve nearly all the Oxide of Gold, and then adding a large quantity of crystallized Oxalic Acid, and boiling the solution. All the Gold is thrown down as a *spongy* mass, which, on being washed, is quite pure, and when pressed or hammered, becomes quite solid. — (Am. Jour. Science (2) 6–187.)

The action of Electricity on different solutions of Gold is very interesting. Among other phenomena of less importance, I will here mention that Electricity can be used for dissolving Gold in Salt water in presence of Peroxides. The Chloride of Sodium is decomposed, and the Chlorine seizes upon the

Gold and forms a soluble salt, while the Sodium oxidizes and forms Soda. At a future time I shall have occasion to say more on this interesting subject.

Gold has been known from the earliest times; the ancients called a native alloy of Gold and Silver "Electrum." Vertruvius and Pliny describe the amalgamation of Gold. The alchemists — Basil Valentine, for instance — were acquainted with the solution of Chloride of Gold, and with fulminating Gold; the latter compound has been more exactly investigated by Scheele, Bergman, Berzelius, and Dumas. Andreas Cassius and his son in 1865 described the preparation of Gold purple which was then adapted by Kunkel to the preparation of red glass, and afterwards in a variety of ways. Proust and Oberkampf discovered the Teroxide of Gold, and examined many of the chemical characters of its Hydrochloric Acid solution; the latter also discovered the Sulphide of Gold. Berzelius discovered the Protoxide and Protochloride; Pelletier, the Protoiodide, and the mode of preparing the pure Teroxide; Johnston, the Teriodide; Balard, the Bromide. Besides the Chloride of Gold and Potassium discovered by Javal, and the Chloride of Gold and Sodium discovered by Figuier, several other corresponding salts have been made known by Bonsdorff and Johnston.

This is a short history of the *Auro Family relationship.*

We will now take up the last point of our subject, the *extraction of the Gold* from the various ores, and the treatment of the tailings.

The experience of the last five years (and a bitter experience indeed, it has been for many) has taught us a lesson; namely, not to engage capital in a business before we understand it, practically as well as theoretically, at least in its most important parts.

The manner in which gold-mining companies have been *raised* (quite an appropriate name for such an operation), during the Gold epidemic in this and other cities, is too well known to be here mentioned, and I will only draw a pencil sketch, describing one of the many offices down town, where stock certificates of the many reported flourishing Colorado, Montana, and other Gold companies were sold to the poor pigeons who, attracted by the flattering and glowing report of an *uninterested fashionable friend*, called at one of these praised bowers of wealth.

Imagine yourself stepping into a large, well-lighted, and splendidly furnished office on Broadway. You see several mahogany desks (such as Presidents only use), with soft cushioned arm-chairs *for confidential chats* placed beside them, and a large table, made of some expensive wood, in the centre. Heaps of glittering and sparkling ores (the so-called Fool's Gold of the miners), Sulphurets of Iron, Copper, and Lead are, as if accidentally thrown there, ingeniously arranged so as to give the unsophisticated stranger at once a startling idea of the immense wealth of the company's mines. Several gentlemen, dressed in the height of fashion, mostly headed by a venerable president-looking individual, are seated at their respective desks, the old gentleman occupying the private office in an enclosure. Whenever a stranger enters the office, all is bustle and business. You see enormous ledgers, stock-books, checks, and letters ready to be handed down at a moment's notice; errand-boys and clerks appear and disappear rapidly (of course some bringing in heavy orders for shares of stock), and the superficial observer is impressed with the extent and importance of the business. The President, after some minutes' delay, admits you to his sanctum, and, with a most winning way and benevolent condescension, explains to you the enormous income that will be made by the Company after all the machines that have been sent out are put to work. Just then the Cashier hurriedly appears, and holding up the bank-book to the President in such an ingenious way as to let you, too, see the large balance in favor of the Company, asks, in audible whisper, of course, if there are any more deposits to be made, the shares of the Company being all sold with the exception of a few odd shares, which, however, have been spoken for by some banking house, and will be sold next day. Few gentlemen, I believe, left the office without having purchased the *few odd shares* as a great bargain, and after some time they have found, to their great mortification, that the beautifully engraved certificates were the fancy representatives of some "wild-cat" company. Of course the fashionable, uninterested friend, who took you to see the Elephant, gets a good commission, and is ever ready, should you meet him again, to tell you with woful countenance, *that he, too, has lost heavily.*

Can we wonder, my friends, that our capitalists become shy and adverse to mining enterprises? As one bubble after the other bursts, and the blissful ignorance of the companies becomes known, we cannot blame anybody for holding back and asking for better information.

When this pernicious, wild, and speculative excitement shall have died away, Gold-mining will be carried on as a regular business, depending not from the sale of shares of stock, and the ups and downs of the stock-market, but from its own products.

Knowledge is spreading rapidly. The well-managed Mining-School in this city, and other private institutions (we have enough costly and corrupt government institutions, and think a Mining bureau a superfluity), will soon make their healthful influence felt in our mining regions. They well deserve the thanks and encouragement of the nation.

Let us return to our subject, *Gold*, and examine into the various systems used for extracting Gold from its ores.

The various methods of working Gold ores can be divided into three classes, the mechanical, the chemical, and the mixed, combining the use of both methods.

The *mechanical* method is certainly the simplest, and consists in crushing the ore to powder, by means of stamps or crushing-machines, and in extracting the Gold by means of amalgamating the precious metal with Quicksilver or Mercury. The more perfect the crushing and pulverizing process, the better, of course, is also the result obtained by the amalgamation. The crushing of ore is mostly done by the well-known old-fashioned stamp-mills. Some use steam or compressed air stamps; some adopt Whelpley and Storer's centrifugal crusher and pulverizer, all of which seem to be improvements on the old stamp-mill, and certainly work well where they are in good hands and connected with machine shops and foundries. A new crusher (Wagner's Patent) is now on exhibition in this city, and works as well as any other I have yet seen. The principal feature of this machine is the ingenious manner of crushing the ore *by attrition;* this is by rubbing the one piece of the stone with the other. I have seen four hundred pounds of hard quartzose Mexican Silver ore pulverized in eighteen minutes' time to a powder so fine that most could pass through a No. 100 sieve. It weighs about four tons, and is very simple and compact in its construction.

The old amalgamating system of running the pulverized ore with water over amalgamated Copper plates is now gradually giving way to more perfect, though more complicated methods. Some run the ore into variously constructed pans, where, with assistance of heated water, a more perfect mechanical mixture of the ore with the Mercury is obtained. This is more especially the case since Professor Henry Wurts, of this city, has made the interesting discovery that the addition of a small portion of Sodium metal to the Mercury increases the affinity of the Gold for the amalgam; in most cases a considerably increased yield of Gold has thereby been obtained. The Freyburgh barrel, as well as Wykoff's process of boiling the ore with Salt Water and Mercury, whereby some of the Sulphurets are decomposed, have, when carefully worked, given good results. Another, the "Staats Amalgamator," treats the pulverized ore in a closed and heated revolving iron boiler, with Steam and Mercury (in vapor form), whereby also very favorable results are obtained. I beg to mention here my own recently-invented Gold Extractor, whereby in twenty-four hours ten tons of tailings or pulverized ore can be worked *by one man* at a cost not exceeding *fifty cents* per ton. One of these machines (engine and boiler 6 hp. not included) can be made for one thousand dollars. The cost of amalgamating by the most ordinary method is about one dollar per ton.

My Gold Extractor has one great advantage over others, and this is *that no handling of plates nor separate distillation* is required, the same all being done automatically. The retort is connected with the Mercury-bath in such way that the amalgam can be run into the retort and the Gold obtained without disturbing the operation by distillation in vacuum. A very efficient chemical agent *assists in decomposing the Sulphurets.*

We will now take up another system of treating the Gold ores, — *the chemical method.* We will subdivide it into the wet and dry, or fire treatment. The wet method we will call that by which the Gold is extracted from the ore in the form of an aqueous solution, the so-called *Chlorine process.* As, however, this treatment requires mostly a previous *roasting* of the ore, we will give at first to this interesting topic some attention.

We have, in the first part of this pamphlet, shown that when Sulphurets in powder form are treated with Mercury the Gold was very imperfectly amalgamated, and could not all be extracted, only a comparatively small amount of the precious metal uniting with the Mercury ; and that a perfect and careful *roasting* of the ore is required, as well as also a condensation of the resulting vapors. I studied carefully the various processes in use, such as Keith's, Whelpley and Storer's, Dr. Hagan's, Crosby and Thompson's, Dr. Ott's Ryason's, and several others, all of which are said to give perfect satisfaction. We will only give to them a rapid glance without comments.

The furnaces of Messrs. Whelpley and Storer in Boston have been described in most of our mining journals ; they certainly look as if they could do some good work when properly managed. The ore, finely pulverized in their centrifugal crushing and pulverizing machine, is blown, together with charcoal-powder, down a vertical shaft or tower, the gases condensed, and then treated for the different metals. Keith oxidizes the pulverized Sulphurets by air in an upward or horizontal direction. Crosby and Thompson do the same in a revolving retort ; they condense most of the volatile products. (I learned lately that they get from the condensed smoke as much Gold as they extract from the roasted ore.)

A very neat arrangement for roasting has been patented, and is now being tested in Washington, D. C., by Dr. Adolph Ott, of this city. The Sulphurets pass successively through three separate superposed furnaces, in which automatic stirrers keep the ore in motion, and cause it to fall from one oven into the other, receiving three successive treatments, by which the ore is fully decomposed. The lighter metals, Zinc, Antimony, Arsenic, and Bismuth are condensed in separate chambers, and the Sulphurous gases subjected to a spray before they are allowed to escape through the chimney. The desulphurized ore is then moistened by steam, and placed into a large tank, where it is treated with *Oxychlorine Gas*, which rapidly converts the present Gold into a soluble salt, the Terchloride of Gold $Au\ Cl^3$ which is leached out afterwards, either by pressure or by a centrifugal machine. The solution is then treated with Sulphate of Iron, or other precipitant, and the pure Gold taken from it as a dark brown powder. This is quite an improvement on Prof. Plattner's successful chlorination process, and shows that the originator understands what he is about. This process is also adapted for the treatment of Silver ores.

Dr. Hagan's desulphurizing process with Hydrogen Gas and Carbonic Oxide and Acid, produced by previous decomposition of steam by carbon, is, as I learn, worked quite successfully for two years past in both Grasse Valley, Nevada Co., California, and Plymouth Ledge, in the same State. The *Eureka* or *Ryason* process is also said to work well in the Mariposa State in California. In this process, I learn, the desintegration, desulphurization, and extraction of Gold by amalgam are all produced by the action of heated Steam and Mercury vapor on the ore while in a closed vessel, and the tailings run over a peculiarly constructed shacking table, so as to concentrate all the amalgam.

We will now pass finally to another system, the *smelting method.* When a rich Gold ore is heated in a reverberatory or other furnace, and an appropriate material as flux added, the ore melts with it to a *liquid mass*, in which the specifically heavy Gold will collect, melt, and sink to the bottom. Soda, Lime, Oxides of Iron have been extensively used, and some to great advantage. By my experiments with the so-called *Stevens Flux*, the residuum from the Cryolite when worked for Soda, I have been brought to the new idea that Gold must exist in nature as a Silicate of the Oxide of Gold chemically combined, for, by treating the same ore with other agents (fluxes that do not *fully* decompose Silica), I could not obtain the same results.

This Stevens Flux is superior to the natural Fluorspar, because it contains *free* Oxyfluorine Gas, which has been absorbed by Lime in a similar way as Chlorine is taken up by it in the Bleaching Powder, hence its greater efficiency.

The Fluorine has such affinity for the Silica that it leaves the Calcium, drives off the Oxygen, and combines with the Silicium to form Fluor Silicium and Fluosilicic Acid. The Calcium takes up the Oxygen and forms Lime.

I have lately seen some astonishing results produced by the use of this Flux with Nova Scotia and Georgian ores.

Mr. H. G. Hubert, of this city, has recently patented a system of furnaces, in which he uses a mixture of flux and ore as continuous lining of the furnaces (either cupola or reverberatory) with an impervious carbon-bottom. This system cannot fail to come into use when this peculiar method of smelting shall have been better known and appreciated.

From the foregoing pages you will see that I have taken some pains to keep posted; I may add that during the last three years I have visited many mines, mills, and metallurgic establishments, and have made numerous experiments in my own laboratory. Taking all points, the defects as well as advantages of the afore-mentioned processes, into consideration, I have followed an entirely distinct road to arrive at long-desired results, — the extraction of *all* the Gold, with most advantageous utilization of the refuse.

By a series of new processes, recently secured by Letters Patent, I can not only obtain a complete solution of the quartzose ores *in water, but also a complete chemical decompo-*

sition of the Silica itself, so as to eliminate *all that Gold that has hitherto been lost*, because I believe that it exists in the Quartz in chemical combination.

The best feature, however, and that which distinguishes *this process* from the old Quartz dissolving processes, is that the *Hydrate of Silica* which I obtain (having no alkali), and which I receive as refuse, can be used for something better than for adulterating soap, and is worth, at least, *one dollar a gallon*, if sold only for a *fire*, *water*, and *weather-proof paint*, to say nothing of its use in the manufacture of *cast* (*not compressed*) *flint-marble* in the shape of statuary, fountains, mantels, tables, monuments, floors, and ornaments of all kinds.

There are numerous other processes in existence, and I shall take pleasure in mentioning them in a future larger publication on this subject after my return from an information trip to Europe.

I cannot close without mentioning the merits of my esteemed friend, Professor Benjamin Hardinge, of this city. This gentleman, by nature gifted with a truly Websterian memory and versatility of conversation, of most industrious habits and extraordinary perseverance, coupled with an irrepressible fondness for anecdote and good-humor, has been the first to dissolve a large quantity of Quartz in water (1853–1857). The improvements which I have since made enable me not simply to dissolve, but to *chemically decompose* the siliceous ores. To the facilities for study and experiment which my friend has afforded me during the last twelve years, I am greatly indebted for what I have learned, and desire, from my whole heart, that he may find the due reward for his long years' labor. I have now combined my efforts with the long and varied experience of my esteemed friend, and look forward to the time when we shall be able to establish the full value of our combined processes.

A. L. FLEURY'S AND BENJAMIN HARDINGE'S COMBINED PROCESSES FOR WORKING GOLD ORES, AND USING THE LIQUID SILICA IN THE ARTS.

The four American Patents, in which an Interest is offered, cover the following operations: —

1. Complete desulphurization of Pyrites and Metallic Sulphurets.
2. The Extraction of Gold and Silver from desulphurized ores or tailings by a new system of amalgamation.
3. The Solution and chemical Decomposition of the Quartzose Gold ores in the wet way, and without the use of either Soda or Potassa, by an entirely new process.
4. The utilization of the refuse material for fireproof Porcelain paint, floors, pavements, and all kinds of ornamental Stone and Marble work.
5. The manufacture of Sulphide of Silicium and Hydrate of Silica with its many uses either made from sand, silicates, or quartz, and utilizing the Sulphur obtained by the Desulphurization of the Sulphurets.

We will consider the advantages of these processes over all others now in use, and speak: —

1. *Of the System of Desulphurization.* — In our combined process we desulphurize the ores in a *complete* manner, be-

cause we firstly bring the ground Sulphurets in close and *most intimate contact* with *Carbon* and *Hydrogen*, whereby the various complex sulphur combinations are broken up *into more simple compounds*, and are, when the ore is treated with alternate *jets of air* and *steam*, made much more ready to give off all the Sulphur, while the Gold is kept back with the Carbon.

2. *The Extraction of Gold by amalgamation* is performed by passing, by *hydrostatic pressure*, the pulverized ore, after it has either been treated with chemicals, or been desulphurized, *in contact with hot water*, and thoroughly stirred, THROUGH *a heated bath of Mercury*, bringing thereby *the water* as well as *every particle of ore* into *close contact with the Mercury.* We *use no Copper-plates*, and have our apparatus so arranged that *the Mercury that carries the Gold flows by its own weight* into a retort, where, by a simple vacuum arrangement, the *Mercury is distilled back again*, from whence it came, and the *Gold and Silver are left in the retort.* This is all done *automatically* and *without additional cost.* One machine capable of treating 10 *tons of ore per day*, with only one man (at a cost of 50 cents per ton), can be constructed *for* $1,000. A *portable machine* connected with a five horse power engine, with a capacity to work 10 tons of *tailings* per day, can be made *for* $2,000.

3. The NEW *Quartz dissolving process* differs from all others in *several distinct features: a. We use neither Soda nor Potassa. b.* We do *not only liquidize* the *Quartz in water*, but *decompose chemically the Silica as well as Silicates*, and thereby liberate not only the *free Gold, but get also that which in many ores is chemically combined* and locked up in the refractory matrix. *c.* The *refuse*, the *liquid*, from which, by passing it through my amalgamator, we first abstract all the Gold *is not thrown away, but utilized* by *Mr. Hardinge* in *various ways.*

One ton of Quartz yields *about* 900 *gallons* of a *Hydrate of Silica*, which, when mixed properly with Oxide of Zinc, or other similar materials, forms with them a *cheap* and *fire-proof Porcelain Paint*, and replaces Linseed Oil or Spirits of Turpentine. This alone, *without mentioning* the adaptability of this liquid for the manufacture of *ornamental Flint Marble*, by casting the liquid, mixed with sand and proper crystallizing agents, *into moulds* like Plaster of Paris, gives to the *Hydrate of Silica* a value of at least $1 *per gallon.* The *profit* derived from the sale of this article is *by far greater* than *the cost of treating the Quartz*, and if we take into consideration the facility with which select Quartz can be shipped to *Boston* and *New York* from *Nova Scotia* and the *Atlantic coast*, and the demand for *Fire*, *Water*, and *Rot-proof Paint* and MOULDED *Stones*, *Statuary*, *Fountains*, *Floors*, *Roofs*, *Pavements*, etc., we cannot but feel confident of the success of this our enterprise.

4. The treatment of pure Silica by the last-named, *Sulphide of Silicium-process*, for the purpose of obtaining a *pure Quartz solution*, a *Hydrate of Silica*, *without alkali whatever* (the water supplanting the base), has still another and very valuable advantage, for by it *all the Sulphur* that is *ejected* by the *desulphurization* of the *Sulphurets* is therein *utilized.*

From this very condensed statement, it can be seen that these combined processes show: 1. *Great Economy*, because nothing is lost; all the refuse is made valuable.

2. *Great saving of time and labor.*

3. *Effectiveness and increased yield of precious metals over and above other processes*, because, as the Silica that holds the Gold either in fine diffusion or chemical combination is in this process *completely decomposed*, ALL THE *Gold can be extracted.*

4. AN UNPRECEDENTED PROFIT. The utilization of the hydrated Silica, as well as of all the Oxides, Vapors, etc., can clear a large profit, and reduce the expense of extracting the Gold from *a ton of ore* (which will cost about $10 a ton) ACTUALLY TO LESS THAN NOTHING, for the *sale* of the liquid from the working of *one ton* of ore can scarcely bring less THAN $900! *What business, we ask, can exhibit such revenue?*

We are now desirous to introduce these processes into practical use, and for that purpose we offer an interest in the above-named Patents and Inventions on liberal terms. For further information, address either Benjamin Hardinge, *New York*, or, A. L. Fleury, 60 *Sudbury St.*, *Boston.*